

Mathematical Lectures

Being the
First and Second,

That were Read to the
Mathematical Society

AT

Manchester.

By the late Ingenious Mathematician *John Jackson*.

*Who can Number the Sands of the Sea, the Drops
of Rain, and the Days of Eternity? Eccclus. 1. 2.*

*He that telleth the Number of the Stars, and cal-
leth them all by their Names, Psal. 147. 4.*

MANCHESTER:

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Printed by J. B. Gurney, at the University Press, Cambridge.

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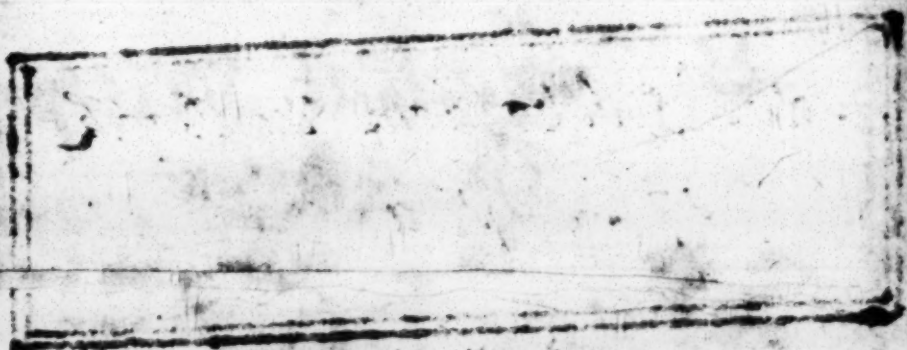
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John Sidebotham his Book

1725 p^r. a

1 Mathematical

2 Dissertations upon
the ingraftment of
the Small Pox.



authenticated as
First Book, printed in Manchester

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TO THE
Vertuous and Religious
Lady *B L A N D*,

Patronefs and first Subscriber to these

MATHEMATICAL LECTURES.

Which are Humbly Dedicated by

YOUR LADYSHIP'S

Very Humble and

Obedient Servants

The Revisers.

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T H E
P R E F A C E
T O T H E
R E A D E R.

TH E R E having been lately set up in Manchester, a Mathematical Society, which was Encourag'd by many, (and some Honourable) Subscribers; and the Composing of the Lectures being undertaken by the late Ingenious Mathematician Mr. John Jackson; and he having discharg'd himself well becoming his Parts and Character in the Reading of several Extraordinary ones in Arithmetick and Geometry: We thought it wou'd be great Pity, as well as Ingratitude, to let such worthy Performances expire with him: So that at once to oblige the Publick, and vindicate the Ingenious Undertaker's Assiduity from the Calumny of the Ignorant and Spightful: We thought it proper to Publish Two of his Lectures, viz. the First and Second, the Sum and subject of which are as followeth.

In the First Lecture, he assures us in the first Place, that the design of forming the Society was for no private Interest, nor any other End, than the Improvement of Young Gentlemen and Others in Mathematical-Learning, &c. upon which Account he hopes (and We think with good Reason) that the Undertaking will succeed well; and having in a few comprehensive Words evinc'd the usefulness and advantage of a Society; and how much it wou'd conduce

The P R E F A C E:

duce to the Improvement of each Member, to have the Joint Assistance of the Whole; he proceeds to give us a Particular Account of the Antiquity, Excellency, and Progress of the Mathematicks; Tracing it from its Birth, to its present Maturity. In the next Place he comes to consider the Usefulness of Arithmetick and Geometry, both as they are pure Mathematicks, and as they come in Conjunction with other Parts, which are called Mixt Mathematicks; and so going on with the Enumeration of all the Parts, shewing all along their Usefulness, and Coherence one with another; and afterwards, after what manner they ought to be Studied, with which he does (with Submission to the Learned) very Ingeniously conclude his First Lecture.

The Second Lecture is Usher'd in with such Definitions as are necessary for the understanding of the said Lecture; which endeavours to find the beginning of Number; and after several Pro's and Con's settles it somewhere betwixt a Cypher and an Unit, according as our Conceptions are capable of Dividing, and Sub-dividing an Unit into Parts; and then proceeds to the Original, and Definition of the Nine Characters called Digits; shewing how by their Concretion vast large Numbers may be Generated, and being so Generated, shews a most excellent Method, and concise Rule for Numbering, or Valuing the largest Number that Fancy can possibly Conceive; And concludes with an Elegant Encomium on the Excellency of Numeration.

And thus We have given you a short Account of what will at present, be Publish'd; which if it meet with Acceptance according to our Expectation, we shall be Encourag'd to proceed in the Printing of more

The First

LECTURE

That was Read to the *Mathematical Society*, at
Manchester, &c.

GENTLEMEN,

IT is a great Encouragement for those Persons who wou'd take the Pains to make Themselves Masters of any *Science*, to be first inform'd of what Use and Advantage it will be to Understand it. And since there is no Part of humane Learning of so real and universal Benefit to Mankind, as those *Sciences* of *Arithmetick* and *Geometry*, it will therefore be very reasonable (after we have shewn the design of forming this Society,) that We give some short Account of the Original of these noble *Sciences*, from some of the ancient Authors; the Fundamental Principles upon which they are rais'd; also the Advantages that continually flow from a due Application of them, to the concerns of *Humane Life*. And lastly, after what method they ought to be Read.

The design of forming this Society is for no private Advantage or other End whatsoever, than
 the

the Improvement of Young Gentlemen and Others, whose aspiring Genius spurs them on, through the Ardent desire they have for that Sublime and Excellent Study of the *Mathematicks*.

We flatter our Selves with hopes of succeeding in this our Design, by the earnest desire We have of seeing this most useful and wonderful Art flourish; which is, and always has been, the distinguishing Character of the most Polite, Ingenious, and Learned Men of all Ages. Also the great Inclination We find in the Minds of Men in this present Age, towards the Study of the *Mathematicks*, makes us to form this Method for the Propagation and Promotion thereof.

The necessity that Gentlemen are under, that would be Considerable in the Art of War, or any great Employment, (either in Church or State) which cannot well subsist without a considerable Knowledge in the *Mathematicks*; makes them to throw aside several trifling Amusements, and apply themselves to the *Mathematical Sciences*; and the unexpected Pleasures they meet with, do so wonderfully surprize and engage them, that they always after make it as well the Delightful as the Serious Part of their Studies.

As a Society will be very Delightful, so it will be more Successful from the variety of Thoughts, and unity of Judgment amongst several Ingenious and Curious Proficients; great Advantages cannot but arise to every Individual; every good Hint will be easily improved, every Point will more fully be comprehended, and each Science made subservient to one another. The thoughts of the Inquisitive will be kept from Languishing, and the

the single and seperate Labours of all the Society will become the Property of every Person.

This will fix in the minds of Young Persons; what they have already attain'd to; and will most vigorously carry them on to a further Improvement.

But to come to the Matter; *Arithmetick* and *Geometry* are what is commonly called *pure Mathematicks*, and what *Plato* very properly calls the Wings of the *Mathematician*; these two *Sciences* do mutually assist each other, and are the Foundation of all other Branches of the *Mathematicks*, whether *Practical* or *Speculative*, as will be evident when we come to Demonstrate the *Newtonian Philosophy*.

It seems to us very proper, to premise a few Things concerning the Original, and Excellency of the *Mathematical Sciences*; that the Lovers thereof may the better Understand what kind of *Science* it is, to which they are about to Dedicate themselves; and that it may be manifest against those who slight those Things whereof they are Ignorant, of what great Use and Dignity this Knowledge is, which the Wise Men of all Ages have with incredible Study labour'd to attain unto, and become Possessed of. *Josephus*, Book II. Chap. 3. Acquaints us that the *Mathematical Sciences* were the First of all other that were known amongst Men; and that the Posterity of *Seth* understood the Order of the *Heavens*, all the Course and Motion of the *Stars*: *Adam* having Predicted to them a Twofold Destruction of the *Earth*, the first by *Water*, and the other by *Fire*; and lest these Inventions should

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be lost, and not come to the Knowledge of Men in future Ages, they raised two Pillars, the one of *Brick*, the other of *Stone*, and upon them Incribed their Inventions, that if the *Brick* one should be Destroyed by the *Deluge*, that of the *Stone* which would remain, might afford Men an Opportunity of being Instructed, and present to their view, the Things that were Incribed upon it. They say also, that that *Stone* Pillar, which even in our Days is to be seen in *Syria*, was Dedicated by them.

Josephus, *Pliny*, *Diodorus*, *Cicero* and Others say, that the *Assyrians* and *Chaldeans* were the first of Mortals after the Flood, that applied themselves to the Study of the *Mathematicks*. But the *Mathematick* Arts which sprung amongst the *Chaldeans*, with whom they Flourished, were afterwards Transferred out of *Chaldea* and *Assyria* unto the *Egyptians*, by *Abraham*. For when, at the Command of God, he went from his Native Country into *Palestine*, and from thence into *Egypt*; and finding them to Delight in good Arts, and to be Furnished with a very good Wit and Capacity for Learning; he Communicated unto them *Arithmetick* and *Astronomy*, and consequently *Geometry*, which must of necessity precede *Astronomy*. In which Studies the *Egyptians* so flourished, that *Aristotle* doth affirm, that the *Mathematick* Arts were first found out in *Egypt*, by their *Priests*, who by their Employment had Leasure for these Studies. From them these *Sciences* did arrive in *Greece*, and from Learned *Athens* Transported to *Rome*, and from thence did spread over *Europe*, and unto the *Britains*. 'Tis very probable, that that Asser-

tion of *Aristotle*, and the overflowing of the River *Nile* might be the principal Reason why *Geometry* is said to have its first Rise in *Egypt*, as you may observe by the following Discourse.

Geometry Originally signifies the Measuring of the *Earth*, or any Distance, or Dimension, on or within it, but now is taken for the Science of Quantity, Extention, or Magnitude, Abstractedly consider'd, without any regard to Matter. 'Tis Generally believed that *Geometry* had its first Rise in *Egypt*, where the River *Nile* annually Overflowing the Country, and covering it with Mud obliged Men to distinguish their Lands one from another, by the consideration of their Figures, and to be able also to Measure the Quantity of it, as also how to Plot it, and lay it out again, according to its exact and proper Dimensions, both with respect to Figure, and its true Proportion; after which 'tis probable a further Contemplation was made, of those Draughts, and Figures which enabled them to Discover many wonderful and excellent Properties belonging to them, which Speculation by a continual Improvement hath brought it to the Perfection it hath arriv'd to, at this Day. And though many may think that it is come to it's utmost Perfection, yet, We doubt not but by the Industry of Future Generations, it will be very much Improv'd.

This last Discourse pretends to prove that the Rise of *Geometry* did proceed from the Inundation of the River *Nile*, which is altogether Fabulous, as shall be Demonstrated by what follows.

To know the distance of one Object from another has been always found so necessary that Men

could never have liv'd without the Consideration thereof, and marking them in their Memories, or by some Exterior Sign, so that tho' it be pretended (as by the preceding Discourse) the *Egyptians* were the first Inventors of *Geometry*, because they were the first that were under any necessity of preserving the Limits and Extents of their Lands and Possessions either by Figures Traced or Delineated, or by Accounts and Memorials contained in Writing; the Inundations of their Lands, by the Overflowing of the *Nile*, Effacing all other Marks; yet as there was the same Necessity before the Inundated part of *Egypt* was Inhabited, since there was no making any Division, without taking the Measures of the Whole, and of each part, nor any Building of Houses, or Towns, without a true Conception of their Figures, and Regulating them by Measures. It is to be presum'd that the *Science* of Measuring is as old as the World. Man took from Himself the Measures of all other Things; He did not Borrow from others the Names of *Fathoms*, *Cubits*, *Feet*, *Inches*, He presently applied his *Thumb*, his *Foot*, his *Hand* and *Arm* to the Things he would Measure, and so He took from his own *Body* the Dimensions of all other Things, having no Occasion for Books or Masters; and without burthening the Memory with Names or Figures. Thus the same Necessity which forced Men to divide into Shares, make Partitions, and to use Measures which they Borrowed from Themselves, oblig'd them to seek out a Way of reducing Things propos'd to an Equality, in order to come at their Shares; and this way of Reducing Things to an Equality could
not

not be known without an Account of the divided Parcels, or the Measures which were necessary to be Apply'd and Reckoned, in order to proceed in the Divisions with Exactness, and this gave a beginning to *Geometry*.

In all Ages, and in all Parts of the Universe where Learning hath prevail'd, the *Mathematical Sciences* have been Embraced as one of the most Principal, and most considerable Branches of it. And amongst the Seven liberal Sciences, no less than four of them are *Mathematical*, viz. *Arithmetick*, *Geometry*, *Musick* and *Astronomy*. There is no Science in the World that does improve the Mind of Man so much as this, by giving it a true Method, and Demonstrative way of Reasoning, by freeing it from Prejudice and Superstition, by rendering it Exact, and capable of Solving the most obscure and intricate Difficulties : Finally by Regulating the Imagination, and giving the Mind the largest Extention and Capacity that humane Nature is capable of Attaining. The usefulness of this Science is almost Boundless, for there being scarce any Knowledge, Art, or Science in the Universe, but may be Assisted and Advanc'd by it ; And it must be own'd by all, that to this Science all the Advancement and Improvement of Natural Knowledge in these last Ages, and some of the most noble Inventions in the World are owing.

If the *Greeks* have been reckon'd more Refin'd than other Nations, 'tis purely because that by means of this Science, they found the shortest, and most certain Road of becoming Reasonable and Ingenious.

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Socrates, (who was the Ablest of the *Grecian* Masters, besides those of a lower Rank,) always began to Instruct his Scholars in *Geometry*, so that it is more than probable it was by this Science that their Wits were Elevated so far above Others; and now, if here Persons would apply themselves more to *Geometry*, and begin earlier, we might hope their Faculties would arrive to a higher Pitch, and improve to a much greater Perfection.

Admit we should suppose *Geometry* to be without this Advantage, and to leave the minds of Men still groveling in the Dust, it would not however cease to be useful in all sorts of Professions; It is even then more necessary for Men, who Content themselves with a moderate Condition, than for those who have an Ambition to Raise their Fortunes. There is no State of Life that does not require the use of all sorts of Measures, its the Soul of all Trades, all the Arts which tend to the supplying of Mankind with Food and Raiment, subsist only by the Measures of Lengths and Breadths, Circles and Squares. Those whose Lot it is to drive a Trade in Provisions, must know the Measures of Dry, and Liquid Things and their Reductions. *Husband-men* understand Surveying either through Necessity or Practice. *Brewers* understand Gauging, *Masons* and *Carpenters* know how to Lay out, to Measure Angles, Squares, and all the Dimensions of a Piece of Building. They who Work in Wood, Iron or Stone, cannot be without the Knowledge of those Measures. But above all, those who apply Themselves to the liberal Arts, ought never to be without Scale and
Compasses,

Compasses, unless they will abandon their Designs, and be reckon'd as silly as *Brutes*, *Mensuration*, (if we may say so,) is the Reason of all Arts, and of all Performances. And if we take away *Geometry* from any Art, either Liberal or Mechanical, we consequently take away its Soul and Reason that is, in plain Terms, we destroy it.

The Noble Sciences of *Arithmetick* and *Geometry* are the very Foundation of the *Mathematicks*, whose Roots are Number and Magnitude, the Original of one is some Part of an *Unit*; of the other a *Point*. But the Productions of either are Infinite. The *Mathematical Science* specifically appropriate to Number is *Arithmetick*, to Magnitude *Geometry*. From these as two principal Springs are derived many Excellent Arts, useful not only in Natural, Substantial, Accidental, Visible, and Invisible things; but also in things Supernatural and Divine, as the Learned Dr. *Dee* affirmeth in his *Mathematical Preface to Euclids Elements*.

Great *Mathematicians* and *Philosophers* have considered Number, *First*, in Respect of the Creator, Simple, Pure and *Unmixt*, *Secondly*, in reference to Spiritual and Angelical minds, including the Soul of Man; and *Thirdly*, in relation to every Creature, and their simple Constitution, and in the *first* and *second* respect term it Number Numbering; but in the *Third* kind Number Numbered. In the Sense of the two Former, we shall not intermeddle to treat of Numbers, referring it to a more Able and Divine Pen. But in the latter Respect, and that in the Lowest, and most Gross consideration of Number, *viz* in Reference and Coincidence to Visible, Material and Corporeal Things

Things, we will so Illustrate these *Sciences*, viz. *Arithmetick* and *Geometry*, in the following Lectures, that the meanest Capacity may be able to Attain to a true Notion thereof.

Arithmetick is a Science whose Bounty extends farther than any of the rest, for it makes prompt Payment for all the pains we Take, and time we Spend to attain it; because it immediately gives the Demonstration of its Operations, and proposes nothing to be perform'd (to which it is Applicable,) but it does at the same time display the Perfection of its Secrets. It has this in particular, that you may find in each of its Operations, that Perfection which is vainly sought for in the whole Circle of the other Arts without the Assistance of this noble Art of *Arithmetick*; *Trade* would unavoidably go to Ruin and Destruction. What would become of the Affairs of the Nation, if by it, were not kept the publick Accounts, which regard the State of the Common Wealth, as to the Number of Inhabitants, Encrease of Stock, Improvement of Lands, and Manufactures, Balance of Trade, publick Revenues, military Power, by Sea or Land, of which Things no Person can give a true Estimate, without the Assistance of *Arithmetical* Calculation.

By these two Sciences, *Arithmetick* and *Geometry*, join'd with *Trigonometry* are perform'd several parts of the *Mathematicks*; as Measuring, Accessible and Inaccessible Heights and Distances, both by Sea and Land, laying down Plans of particular Lordships, Inclosures, and making Maps of Countries. How Lame and Defective would the Arts of Fortifying, Defending, Bombing, Attack-

ing, Quartering and Embattling of Armies be without *Arithmetick* and *Geometry*.

Navigation, upon which the Riches and Security of the Nation doth wholly depend, is perform'd by *Arithmetick*, *Geometry*, and *Trigonometry*; and therefore if those Arts were lost or unknown, how vain and unsuccessful would the Merchants designs be to fetch home Riches from the remote parts of the World. How could the *Navigator* find his Way through the Turbulent *Ocean*, from one part to another, without the Assistance of *Astronomy*? Or find the *Longitude*, and *Latitude* of the Ship, by the *Sun*, *Moon* or *Stars*.

But as it is needless to say thus much of a *Science*, that illustrates its Uses and Perfections daily: We can do no less than Admire, that any one should be Ignorant of its Excellency, and continual benefit to Mankind, who would not take some Pains to Attain a competent Knowledge in an Art so truly valuable? We are truly Satisfied, that there can be no Thoughtful and Contemplative Person, but what would find Pleasure, and Satisfaction in the Study of it. And for the Advancement of all those who are *Mathematically* inclin'd: We propose this, as the best and most regular Method of Proceeding to Gain a good and perfect Knowledge of these *Sciences*.

Arithmetick in whole Numbers, *Vulgar*, *Fractions*, and *Decimals*, must be truly understood as a Preparation only; and after you have got the perfect Reason and Demonstration of each Rule, you must proceed to Learn the *Mathematicks* as follows.

1. The Elements of *Geometry* contain'd in the first Six Books of *Euclid*, and the Eleventh and Twelfth of the same *Geometrical* Elements; for the first Six Books give you the Reason and Demonstration of the *Mensuration* of *Planes*, such as *Boards*, *Glass*, *Hangings*, *Wainscoting*, *Land* and all other *Surfaces* whatsoever. As also of *Trigonometry*, *Mechanicks*, *Opticks*, &c. of which in their proper Place. The Eleventh and Twelfth Books give you the Reason of the *Mensuration* of all Regular Bodies, and their *Frustums*, *Gauging* of *Vessels*, and finding the Content in Solid Measure, of *Stone*, *Timber*, &c. whether *Cubes*, *Globes*, *Pyramids*, *Prisms*, *Parallelopipedons*, *Cones* and *Cylinders*. As for the other Seven Books of the Elements, which contain the Doctrine of Incommensurables, they may be Omitted, being subjects of Curiosity, rather than such as tend to real Usefulness.

2. Plain *Trigonometry*, is the Second Thing to be Learn'd, with the Method of Constructing the Tables of *Sines*, *Tangents* and *Secants*, both *Natural* and *Artificial*, and the Use of such Instruments as are proper thereto. From this Science flows a wonderful Number of useful and valuable Arts, such as *Altimetry*, or taking the Height of *Trees*, *Towers*, *Steeple*s, *Clouds*, &c. *Longimetry*, or taking the Distances of *Objects*, either by *Sea* or *Land*; *Navigation*, viz. *Plain*, *Mercator*, *Middie-Latitude* and *Traverse-Sailing* are perform'd by *Trigonometry*. *Fortification*, *Opticks*, *Dioptricks*, *Catoptricks*, a great part of *Mechanicks*, and several other Things

Things in *Astronomy*. We say, these Things are nothing else but the Handling of a plain *Triangle*, by giving the Sides and Angles various Names, according to the particular Art it is applied to.

3. To Learn the other *Sciences* proceed next to the Principles of *Astronomy*, which contains the Doctrine of the Celestial and Terrestrial *Globes*, and the Explication of the *Phænomena* of the *Heavens*, from the true Principles thereof. Secondly, To *Spherical, Trigonometry, Geometrically* and *Logarithmically*; and the Application thereof to *Astronomy*, with the Resolution of Questions of the *Sphere* by Calculation, and *Geometrical Construction*; from whence flows the Art of *Dialing, Great Circle Sailing*, and several useful *Problems* in *Geometry*.

4. The Theory of the *Planets*, to determine their *Orbs*, by *Observation*, to describe and construct the Tables of their Motions, and to shew the Uses of them in finding the places of the *Planets*, the *Eclipses* of the *Luminaries*, the *Approaches* of the *Planets* to the *Fix'd Stars*, &c.

5. *Algebra*, both *Literal* and *Numeral*, with the Application thereof to *Geometry*; also the Method of Resolving and Constructing plain and solid *Problems*: As also of Indeterminate, or the *Diophantean Problems*.

The Sixth thing to be Learn'd, is *Conick Sections*, that is the principal Properties of the *Parabola, Hyperbola* and the *Elipsis*, for upon the chief Properties of these *Sections*, the Sublime parts of the *Mathematicks* do wholly depend; such is the *Newtonian Philosophy*, &c.

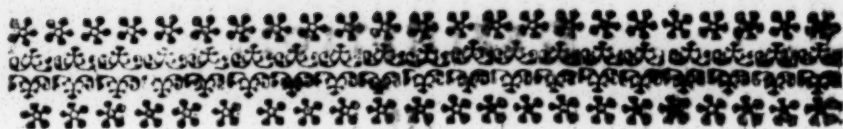
? Then

7. Then having Attain'd to a Competent Knowledge in *Algebra*, the Elements of *Geometry*, and *Conick-Sections*; the next Thing to be considered is the Doctrine of *Fluxions*, with their Application to the drawing of *Tangents* to *Curves*; Investigating the *Areas* of *Surfaces*; Resolutions of Questions, *de Maximis & Minimis*; finding the Points of contrary *Flexion* and Retrogration of *Curves*; Investigating the Dimension of *Bodies*; describing of *Cauſticks* by Reflexion and Retraction to all sorts of *Curves*; The Investigating the Centers of Gravity, Percussion and Oscillation of *Lines*, *Surfaces* and *Solids*; The use of *Fluxions* in *Astronomy*, *Mechanicks*, *Dioptricks*, *Catoptricks*, *Navigation* and *Gunnery* are Numberless. What wonderful! Nay almost Incredible advances *Natural Philosophy* has received, since it began to Flourish, is apparent to those that have been but a little Conversant in the profound Writings of that Great and Celebrated Geometer Sir *Isaac Newton*, whose Immortal Genius, will be a lasting Ornament to the *English Nation* in future Generations. For as all Noble Inventions and Discoveries, (besides the Honour they bring to their immediate Authors,) fix an Everlasting Character of Glory upon the Country that first produced them; So there's no doubt but *England* upon this Account, will be Famous to Posterity.

August 11 & 12th

1718.

T H



The Second

LECTURE

That was Read to the *Mathematical Society*,
at *Manchester*, &c.

DEFINITION.

I.

QUANTITY signifies any Thing
whatsoever, that is capable of Estima-
tion or Mensuration.

1st, In respect to the Habitude or Quality
of a Thing, such as the Length, (considered
as the Quantity) of a Rope, the Weight of
a Stone, the Multitude of Apples on a
Tree, &c.

2^{dly}, In relation to the very Being it self,
if compared with any other Being of the same
kind; it may be said to be Greater, Lesser, or
equal to it. As one Man is said to be Greater
than Another, one Tree than Another, one
House than Another, &c. But as there is se-
veral Kinds and Divisions made of *Quantity*,
so we shall take what is proper for the Subject.

De.

DEFINITION.

II.

DISCRETE Quantity has for its Object any thing whatsoever, whose Parts are Seperate and Distinct, as it were infinitely divisible, or its better defin'd to declare *How many?* What *Number* or *Multitude* of *Quantities* there are? as tho' it was rather to be called *Quodity* than *Quantity*; which is the Subject of *Arithmetick*.

DEFINITION.

III.

ARITHMETICK is a Science which has for its Object *discrete Quantity*: Or it shews us what *Number* of *Quantities* there are contained in any other *Quantity* or *Quantities* of the same Kind: And Teaches us the Art of *Computation* or *Reckoning* by *Numbers*: But *Arithmetick* consisteth of two Parts, *viz.*

1st. Theorical or Speculative *Arithmetick*, which is an abstracted Contemplation of the Essence, Nature, Property and Affection of *Numbers*, seperate from any Manner of Subject.

2^{dly}, Practical *Arithmetick*, which is the Reducing of those Rules, (discovered by Speculative

Speculative) to Practice, that is by applying them to some Subject.

DEFINITION,

IV.

NUMBER will be easier and better defined after we have considered *Euclid's* Definition, who saith, that *Number* is a *Multitude* composed of *Units*, and an *Unit* or *Unity* is whatsoever is said to be One; as being a single individual Part of discrete Quantity: Or its the Idea we have of any one individual Thing of a particular Kind or Name; as one Man, one Stone, one House, &c. which is ever represented by the Figure [1] One. And when we consider more than one of these individual Things joined together, we rightly conceive what *Euclid* asserts to be *Number*: For thus we have a Number of Men, a Number of Trees, &c. This is the Collection or *Multitude* of *Units*, in which sense *Euclid* defines *Unity* to be no *Number*: Tho' its the Part of a Number, viz. The half of Two, as Two is the half of Four. But then this Part is took to be concrete or indivisible, as having no Parts; and so is called the beginning of Number.

Euclid never denies *Unity* to be *Number*, but Treateth of it in the same Sense in which he does the rest of Numbers; and his word *Multitude* if taken in a looser

A Unit
or Unity
what,

How called
led the
Beginning
of Num-
ber.

Sense

Sense may allow *Unity* to be assigned as *Number*: For perhaps *Euclid* may be understood of *Unity*, not as it means One or the Singular Number; but as it were the common *Denomination* or *Denominator* to all Numbers: as thus [4] *Four* is the Value of so many *Units*; here *Four* is the Number or Multitude: *Units* the Denomination. And [1] *One* is the Value of one *Unit*, *Unity* is the Denominator of Number; *One* is the Number as the Multitude of *Units*. For its one Thing to deny *Unity* to be Number, or Part thereof; and another to deny *One* to be Number: For *One* is certainly as much a Number as Ten, Twenty, Thirty, &c. which are but One, Two, Three Decades, &c. and its altogether possible *One* may be answered, when it is enquired concerning Multitude. For if it be enquired of the Parent of an only Son, how many Sons he hath (i.e. what will express the Quantity) its answered *One*: In which sense *One* Answers the Question how many? and in this sense *One* (as it is a *Unit*) may be called a Multitude; and therefore it is a Number, but it is least of all, which firmly Answers the Question how many? and hence its

One is
the First
Number.

the First Number and least Multitude

Its true indeed that *Nullity* or *None* sometimes Answers the Question how many? if it be enquired how many solid Orbs of the Heavens there be; it will be Answered (not unwisely) *None*: And tho' it An-

wers

swers the Question, yet it does not hence follow that *None* is Multitude; because it answers Negatively: And the Question is improper; for it ought to be first enquired if any! before how many? or it takes away the subject of the Question, and Answers not how many *Units* there are when there is not a *Unit*; as he who says there is no *Orbs*, denies that there is *Orbs*: for if there be any at least it will be *One*.

But there are a great many *Middle things* between *One* and *None*; yet of these the Question is not properly how many? but *how much*? Which is *continued Quantity*. For if it be enquired how many hours have passed since *Nine*; when one Quarter or one half Hour hath past, it is not Answered concerning *how many*? But concerning *how much*? and so it is in all other Questions, where these *middle things* or Parts are concerned. Therefore from hence we draw that *One* or *Unity* is the least Number, and that neither a *Part* (by some called a *Fraction* or broken Number) nor *Nullity* can be Number: And yet whatever has been here produced by this Way of Reasoning, not only the *broken Numbers*, but even *Nullity* it self is managed by *Arithmeticians* in the same manner as other Numbers are: and are by them either reckoned for Numbers or as Numbers; and they consider *Unity* so Infinitely or Indefinitely divisible as of its self, to make an *Arithmetick*, and it's smallest Division to be only an unexpressible

A Fraction is said to be no Number.

Consideration which they take not to be any Thing, and in that Sense is said to be equal to Nothing; and this is rather called the beginning of Number than an Unit.

A Cypher what, And so a Cypher, Nullity or Nought signifies that which has no Quantity, and consequently in it self signifies Nothing: But being Annext or put after any other Character or Figure: It augments or decreaseth it in a decuple or tenfold Proportion, and when prefixt or put before whole Numbers, is insignificant and useles: Tho' if prefixt to Decimals, it Decreaseth them in the same manner, as it doth Augment (when Annext to) the Integers or whole Numbers, and is always represented by the Character [0] Nought. Which by some is asserted to be the beginning of Number. For the word *Principium*, or beginning is taken in a two fold meaning at least, viz. as it signifies the *First which is so*, and the *Last which is not*: As if any one should say, Motion is begun either from the last moment of Rest, or from the first moment of Motion. So also if the Right of an Heir to his Inheritance, be said to be either from the Death of his Father, or from the last moment of his Father's Life. This is *Principium Ultimum*, the *Last which is not*, for the last moment of the Father's Life is the last, that the Heir had no Right to his Estate. But if we say, that the Heir's Right begun from the first moment of his Succession. This is *Principium Primum*; the *First which*

which is so. So likewise *Unity* may be called the beginning of Number, as being the *First that is so*. And in like manner is a *Cypher* or nothing said to be the beginning of Number, as being the Negation of all Numbers, and the *Last which is not*. But having asserted before, that *One* is Number, then it cannot be said to be the *Beginning of Number*, nor can a *Cypher* because its not Part thereof.

How called the beginning of Number

But neither *Unity* nor a *Cypher* is.

Number can never be so Augmented, as not to be encreased; nor so diminished, as not to be made less. For its so Pure and Immaterial as not to offer it self to be judged off as other Things are by Sight, neither does it fall under any Sense, or is represented by any Shape, Form or Figure. For its only a Consideration of the Mind and Understanding, which is purely intellectual, and cannot be judged of by any of the Senses. Therefore how difficult will it be to find the Original Fountain of Number: Which the learned Doctor *Dee* saith, hath a certain Original Seed (as it were) of an incredible Property, and of Man, never able, fully, to be declared. Now we would not have any one to think, that we strive about a matter of no Moment, nor that we design to bring all the Arguments *Pro* and *Con* concerning this Subject, but to shew the best Method whereby the most formidable Objections may be easiest Solved.

Nor can it be defined.

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Nor can it be defined,

And we have here avoided those Comparisons, which are usually made between Number and Magnitude: Because neither a *Unit* nor *Cypher* hath intirely the same or like Properties with a Point in Magnitude, neither can Quantities of divers Kinds and Species, be truly compared together.

Number
is defin-
ed by
Way of
Compa-
rison.

Sometimes *Number* is defined by Way of Comparison or Relation to some other Number either equal Greater or Less than it self, as Twelve compared to Twelve is equal, Twenty Four to Twelve is Greater, and Six to Twelve is less. For thus saith the great Sir *Isaac Newton*, by *Number* we understand not so much a *Multitude of Units*, as an Abstracted Ratio of any Quantity to another Quantity of the same Kind, which is accounted for *Unity*: but this Definition directly leads us into the Doctrine of Proportion, which will be treated off in its proper Place.

Number
what.

But besides all that hath been said, it is now necessary to give you a Plain and Brief Definition of *Number*, which we suppose cannot be better defined, than thus: *Number* is what expresseth the Quantity; or what Numbereth up the several Things of the same kind.

And the innumerable Variety of Numbers have caused several various Notes and Characters to be invented, whereby one Number might be more Compendiously and distinctly denoted and known from another: And it's now Established by an Arbitrary

bitrary Law, which at this time is agreed on by the greatest part of the known World, that [1] the First of them be expressed or called *One* : And that *One* and *One* doth constitute another Character, viz. [2] *Two*; and that *One*, and *One*, and *One* makes [3] *Three* the Third Character : and so 4. is called *Four*. 5. *Five*. 6. *Six*. 7. *Seven*. 8. *Eight*. 9. *Nine*. 0. *Nought*. and all these Characters or Figures, (except the Last) were differently formed to represent so many *Units* put together, as was designed each should denote, and [9] *Nine* is the greatest number of *Units*, that was thought necessary to be represented by one single Character, and in whatsoever kind these are taken, either in the Characters as 1. 2. 3. &c. or in the Articular Expressions, as *One*, *Two*, *Three*, &c. they always represent the same Ideas, as they are mutual Representatives of each other, and with the above Characters only, (which are but few) we can denote or represent any Number tho' never so great, by a Wonderful (tho' now a days Familiar) Method ; which shall be shewn hereafter.

The Numeral Characters how constituted,

These Ten numeral Characters, by which we represent Numbers, are those which the *Arabians* used, and yet are by them ascribed to the *Indians* as the first Inventors thereof : And the learned Doctor *Wallis* having found from whence we had them, both then enquire after their *Antient use*,

Of their Ancient use.

in

in these Parts of the World, and upon the whole matter (saith he,) I judge that about the middle of the Eleventh Century, or between the Year of our Lord 1000 and 1100, (now about Six hundred and Sixty Years ago) these numeral Figures came into use amongst us in Europe, together with other Arabic Learning, first on the account of Astronomical Tables, and other Mathematical Books; and then by little and little into common Practice. But not till about the middle of the Thirteenth, as he seems to Assert in his Preface.

The several *Kinds* and *Denominations* of *Numbers*, as they are divided either into *Homogeneal* or *Heterogeneal*; and those again into several sorts as *Digits*, *Articles*, *Primes*, *Compounds*, *Whole*, *Broken* or *Mixt*, &c. tho' a particular Explanation or Definition of each sort would be here too Tedious, yet it shall be delivered, where they become useful to our Design.

Number
how di-
vided.

But number may be taken as divided into three Kinds only, the *Integer* the *Fraction* and the *Surd*. The *Integer* is that which *Unity* measures? the *Fraction* which a Submultiple or Lesser part of an *Unit*, and the *Surd*, to which an *Unit* is incommensurable.

But before we come to *Notation*, commonly called *Numeration*, it will be convenient to declare, that our design here is only to Treat of the *Notation* used in common *Arithmetick*, that we may lay a per-

fect and sure Foundation, in these inferior and low Parts of the *Mathematicks*; till we Ascend and take the rest in Course; to the End we may make every Thing unknown and difficult more speedily attained by means of Things already known and easie; and now we will proceed to the *Definition and Principles of Numeration*.

NUMERATION is the true *Distinction, Estimation, and Pronunciation of Numbers*, or it Teacheth rightly to understand the Notes, and Characters, by which all Numbers are signified or represented; so consequently to Write down the Value of any Number proposed, and also to have a distinct Idea of every Place of it.

We have before shewn the *Distinction, Estimation, and Pronunciation of the numeral Characters*: (which are called *Digits*, because there are as many of them; as there be Fingers on both Hands,) in their own simple Values. For when any one of them stands separe by it Self, it standeth in what we call the *First place*, or the *place of Units*. And should we encrease the greatest of them, *viz.* 9 by one; we shall then have a Number consisting of two Places, which is the least Number, that can be represented by two Characters, *viz.* 10. where the 0. standing next to the Right Hand, is said to be in the first Place, and the 1. in the *Second place*, which is called the *Place of Tens*; in which place any Figure signifies as many Tens as there are

Units

Units in the said Figures, and is expressed *Ten*. But if the 1. were in the First Place, and the 0. in the Second thus, 01. it would only signifie *One*. Thus a Cypher in the last Place on the left Hand is *insignificant* and *useless*: And the 1. being in the Second Place, it is encreased in the *Decuple* or *Tenfold Proportion*, as was mentioned before. Then by a gradual Encrease of one to 10. there ariseth these Numbers, 11 *Eleven*, 12 *Twelve*, 13 *Thirteen*, &c. to 19 *Nineteen*; which encreased by one sets a 2 in the second Place, or in the Ten's Place, viz. 20. and is expressed two Tens, or *Twenty*, and by a continual adding of one to 20, there ariseth 21 *Twenty one*, 22 *Twenty two*, 23 *Twenty three*, &c. to 29 *Twenty Nine*: Which encreased by One sets a 3 in the second Place, viz. 30. which is expressed *Thirty*, and so on to 40 *Forty*, 50 *Fifty*, 60 *Sixty*, 70 *Seventy*, 80 *Eighty*, 90 *Ninty*, &c. which are called *Articles*, because they may be justly divided into Ten equal Parts, and when you have raised the greatest double Combination, viz. 99 *Ninty Nine*, to which one being added, we shall then have a Number consisting of three Places, and the least Number, which can be represented by three Characters, viz. 100. where 0. stands in the first Place, 0. in the second, and 1. in the Third: which is called the *Place of Hundreds*; in which Place any Figure signifies as many Hundreds, as there

are *Units* in the same Figure. Therefore 100¹ is called *one Hundred*; to which if one be continually added, there ariseth 101. *one Hundred and one*, 102. 103. &c. until you come to the greatest treble Combination, viz. 999 *Nine Hundreds Ninty Nine*; to which if One be added, there ariseth a Number consisting of four Places. So the fourth Place is called the *Place of Thousands*; and we may carry them on to the 5th, 6th, 7th, 8th, 9th. &c. Places. That is to any Height which can possibly be assigned. For all Numeration is but still adding one more to the Last: Which gives us another Number with a distinct Name and Character, whereby to know it from any before or after; and to distinguish it from any greater or smaller Multitude of *Units*, and therefore, whosoever hath a Memory to retain the distinct Names and Characters for each Series, or Progression of Numbers, will undoubtedly become an able Proficient in Numeration: Then he may be supposed to diminish or lessen them Gradually in the same Manner, which is all that Number is capable off.

But without Names and Characters all Accounts and Reckonings will hardly be kept from being an Heap of Confusion. *This I think to be the reason (saith one) why some Americans I have spoken with; (who were otherwise of quick and rational Parts enough,) could not as we do, by any means count to a 1000, nor had any distinct Idea of that Number; though they could Reckon very well to 20: Because their Language being Scanty, and Accommodated only to the few neces-*

series of a needy simple Life, unacquainted either with Trade or Mathematicks, had no Word in it to stand for a 1000. So that when they were discoursed with of these great Numbers; they would shew the Hairs of their Head to express a great Multitude, which they could not Number, which Inability (he supposes) proceeded from their want of Names to express those Numbers with. Nor had we formerly in our Language any simple Names beyond that of Millions often times repeated: Tho' now we have got new simple Names, for the better Distinction and truer Estimation of more large Numbers of which hereafter.

But to proceed, every simple Figure is said to have two Values; a *Primary One* in respect to its Form as certain and known. The other a *Secondary One*, as being unconstant and depending upon the Place, where it stands in a Rank with Others: And in the Reading or Expressing of Numbers; great Regard must be had to Express both its *Primary* and *Secondary Value* as 1111. *One Thousand one Hundred and Eleven*, or thus, *Eleven Hundred and Eleven*. Where the first 1, we call simply *One*, but the next 1, we call not *One*, but *Ten*; because in Relation it's as *One*, but in its *Secondary Value* with Respect to *Ten* it's Place. And the 1, in the Third Place is a *Hundred*, that in the Fourth a *Thousand*. And hence it is evident that each Place towards the Left Hand is Ten times the Value of the next towards the Right, for the second Place is Ten times the Value of the first. The third Ten times that of the second, and the fourth Ten times that of the third. But

But that we may have a more true Conception of the Nature, Value and Order of the Characters in their Respective Places. Which will Teach us rightly to represent any Number we hear exprest in Words, or express in Words any Number we find denoted by the Characters, and for a further Explanation or Illustration thereof, we shall subjoin the following Table.

The Value of the Places.

	Hundreds of Millions.	Tens of Millions.	Millions.	Hundreds of Thousands.	Tens of Thousands.	Thousands.	Hundreds.	Tens.	Units.	
										Nine.
										Ninty Eight.
										Nine Hundred 87.
										Nine Thousand 876.
										98 Thousand 765.
										Nine Hundred 87654.
										Nine Million 876543.
										98 Millions, 765432.
Ec.	9	8	7	6	5	4	3	2	1	Nine Hundred, 87654321.
	9th,	8th,	7th,	6th,	5th,	4th,	3d,	2d,	1st,	

The Order of the Places:

To understand or read this Table, you must begin at the Right Hand, count toward the

E 2

Left

Left, with *Units, Tens, Hundreds, &c.* and read from the Left towards the Right; as the Characters represent.

As when we take the third Rank of Figures from the Top, viz. 987. we say *Units, Tens, Hundreds.* and Read it *Nine Hundred Eighty Seven*. Or if we take the sixth Rank, viz. 987654. we say *Units, Tens, Hundreds, Thousands, Tens of Thousands, Hundreds of Thousands,* and read as Above: The like is to be observed in the Reading or Expressing of any Series or Rank of Figures whatsoever.

As in the Example 54021. this Number consisteth of five Places; and we have the fifth Place in the Table for *Tens of Thousands*. Then it's 54 *Thousands* (for the *Tens Places* ever joins the consequent Figure) no Hundred 21.

Example the second, 1501210. consisting of seven Places which in the Table is *Millions*. Therefore it is One Million, five Hundreds, one Thousand, two Hundred and Ten.

And having got the true Idea of all the Places in the Table; which may be vastly Augmented; for the last Place in this Table is only *Hundreds of Millions*; and the next Place in Course is *Thousands of Millions*; after which is *Tens of Thousands of Millions*; and the next is *Millions of Millions*, or *Millions twice repeated*; which in it's new Name is called *Billions*, then *Tens of Millions of Millions*, *Hundreds of Millions of Millions*, &c. And having thus far enlarged the Table, or rather proceeded out of it, we now think it necessary to lay down a Rule, whereby any one may read any Rank or Series of

of Figures he findeth, as easie as he reads a Number consisting of six Places. The *Rule* is this:

Begin at the right Hand, then count to the seventh Place, over which put the Figure 1. which signifies Millions: and taking that Place in, over which the 1. is put, count seven Places more, over which put 2. which is Millions of Millions, or Millions twice repeated, *viz.* Billions, and taking that Place inclusive, over which the 2. is fixt; and count seven Places more; over which put a 3. to represent Millions of Millions of Millions, or Millions three times repeated, *viz.* Trillions, and thus proceed.

Now we shall for the Explanation of this Rule take a Number, which consisteth of 14

2 1

Places, *viz.* 35497196351275. Then as the Rule directs, we count to the 6, over which we put the 1. as you see in the Example, then we take in the 6 as the first place: And so count to the 5. over which we put a 2. which shews the Place of *Billions* or *Millions twice repeated*: And having thus Estimated it by the Figure over it, we begin at the left Hand, and read it 35 *Billions* or *Millions twice repeated*, 4 *Hundreds*, 97 *Thousands*, 1 *Hundred*, 96 *Millions*, 3 *Hundreds*, 51 *Thousands*, 2 *Hundreds Seventy Five*.

5 4 3

Example the second, 1391,724288,887152,

2 1

999425,128493,402200. This is the Number of the Words significant and insignificant, that can be made of 24 Letters; and we know of no Language in the World, which ever was,
or

Or is now in use, that hath so many Words in it. But when we come to read the Number it's 1391 *Quintillions*, or *Millions five times repeated*, 724288 *Quadrillions*, &c.

Octillions, Seprillions, Sextillions,

Example the 3d. 574321. 134567. 194156, *Quintillions*, *Quartillions*, *Trillions*, *Billions*, *Millions*, 159429, 595784. 976874. 879413, 791372, *Units*.

197654. This Number consisteth of 54 Places, and instead of putting down the Characters as they Encrease, we'll give to every *Member* or *Senary* it's proper Name, whereby we shall have a clearer Notion to distinguish every *Senary*, and place in the Number; for thus the last *Senary*, tho' read first is 5 *Hundred*, 74 *Thousand*. 3 *Hundred*, 21 *Octillions*, or *Millions eight times repeated*, and the next *Senary* is 134567 *Septillions* or *Millions seven times repeated*; and so on.

Example the fourth, 1000, 000000, 000000, 000000, 000000, 000000, 000000, 000000, 000000, 000000. Which consisteth of 64 Places, and this is the 1. with the 63 *Cyphers* Annexed, which *Archimedes* Demonstrated, was a Number far greater than the Number of the Sands of the *Sicilian* Shoar, nay if Ten Thousand Sands should go to make one Seed of Poppy, such a Number of them laid together, would make a Bulk much greater than the whole World: So that it would surmount the fixed Stars. And it's read *One Thousand Decillions*, or *Millions ten times repeated*.

But to come to the Reading of more large Numbers, we shall lay down this general Rule, which

which we take to be both a New and concise One, for it saves the Trouble of putting down the progression Characters, and requireth no view of the Figures before you come immediately to read them.

Rule, one sixth of the Number of Places any Number consisteth of, is the Number of Senaries, if there be a Remainder, it's 1st, 2^d, 3^d, 4th, or 5th Place of the fore-mentioned Table, but if otherwise, as when there is no Remainder, the Number of Senaries are to be one Less, because the First Senary doth not end in the first Member of Units, nor doth it bear any Character

And tho' this Rule is not very proper for Numeration, yet we shall here insert it: Because we take it as a finishing Stroke to this Part of it. For *Example*. 1234567898 &c. is said to consist of 150 Places, one Sixth whereof is 25, and nought remains. Therefore according to the Rule it must be one less, Then it's read 123456 Millions 24 times repeated; 789876 Millions 23 times repeated, &c.

Example the 2^d. 5793125 &c. consists of 700 Places, one Sixth whereof is 116, and 4 Remains; which is to signifie the *Thousands Place*. Therefore we Read it 5793 Millions 116 times repeated. &c.

And for the 3^d. Example, we shall take a Number so vastly Great, that if Twenty Figures were set in one Inch; they would contain 63 Thousands, 2 Hundreds 10 Millions, 2 Hundreds 27 Thousands 2 Hundreds, 72 Miles

Miles in Length: And would take 15 Millions, 2 Hundred 10 Thousands 8 Hundred 60 Years in Writing down, tho' there should be Ten Thousands Figures of 'em wrote every Minute. And the Example is this, a 1 with 80000,000000,000000, Cyphers annex, this Number consisteth of 80000,000000,000000 Places, one Sixth whereof is 13333,333333, 333333. and 3 Remains, which shews the third Place in the Table, viz. Hundreds. Then it's read, *One Hundred Millions 13333,333333, 333333. times repeated.* This is one of those Numbers, which Doctor Wallis tells us, *Archimedes* had fitted no Notation unto. But this easie Rule not only fits a Notation to this, but to all other Numbers, and altho' there be seldom or ever any use for these great Numbers in Ordinary Affairs, yet one that would understand both Theoretical and Practical Arithmetick must acquire This.

And to any One that well Understands the Reading of Numbers, it will be no hard Matter to write down the Charecters as they are expressed in Words, which must be done by seeing that every Figure, as it is expressed hath it's true Value, and stands in its proper Place according to its Denomination. As for Example to write the Year of our Lord One Thousand, Seven Hundred and Eighteen: We hear the value One, and the denomination Thousand exprest; which we know according to the order of the Places in the Table, must stand in the fourth Place, and 7 in the third, and 1, in the second, and 8 in the first, Thus 1718.

Example

Example the 2d, to Write down, One Hundred Eighty Seven Thousand, Six Hundred Fifty Four you'll have 187654.

And a *Number* may be expressed in *Words* which cannot properly be said to be Writ down in one *Rank* or *Series* of *Figures* according to the *Expression*. As *Eleven Thousand Eleven Hundred and Eleven*. Which must either be Denoted in Three *Ranks* or in (12111) the whole for which see the Margin.

11000
1100
11

And now we shall Conclude the *Lecture* in the *Words* of a Worthy *Author*, *Notation* would be an *Invincible Difficulty*: But that is prevented by a *Method* so easy to be *Learnt* and *Remembred*; that for its *Excellency* and *usefulness* it may deservedly be *Reckoned* amongst the most *Admirable Inventions*, and yet (for what reason I know not unless because it is *Easy* and *Common*) it's very rare to find it so *Esteemed* and *Observ'd*; but it duly considered it may rather seem to be a more than humane *Discovery*, and to be the *Gift of Him, who is the Giver of all good Things*.

12111

August 19th 1718.

F I N I S

